Biomedical Tele-Immersion for the Next Generation Internet

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- Michael Papka
- Rick Stevens
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Challenges of Surgical Education

- Rapid expansion of knowledge
- Limited availability of biological materials
- Limited availability of expert educators
- Increasingly specialized procedures
- Application of teleconferencing, telepresence, and virtual reality

Three-Dimensional Anatomy

- Highly complex
- Critical to understanding common problems
- Surgeon's conceptual visualization difficult to achieve with lectures, 2D illustrations or photos
- Cadaver dissection also difficult
- Few local experts in any region

Broad Goals

- Implement Tele-Immersive environments to teach selected anatomical relationships and manipulate radiological images
- Evaluate this method of instruction by assessment of knowledge gains, user satisfaction, process measures and costs

Tele-Immersive Virtual Reality

- Two or more ImmersaDesk^{TM} systems
  - stereo vision
  - viewer centered perspective
  - large angles of view
  - interactivity
- Networked collaboration (using CAVERNsoft)
  - converse, see each other, and point in 3D!

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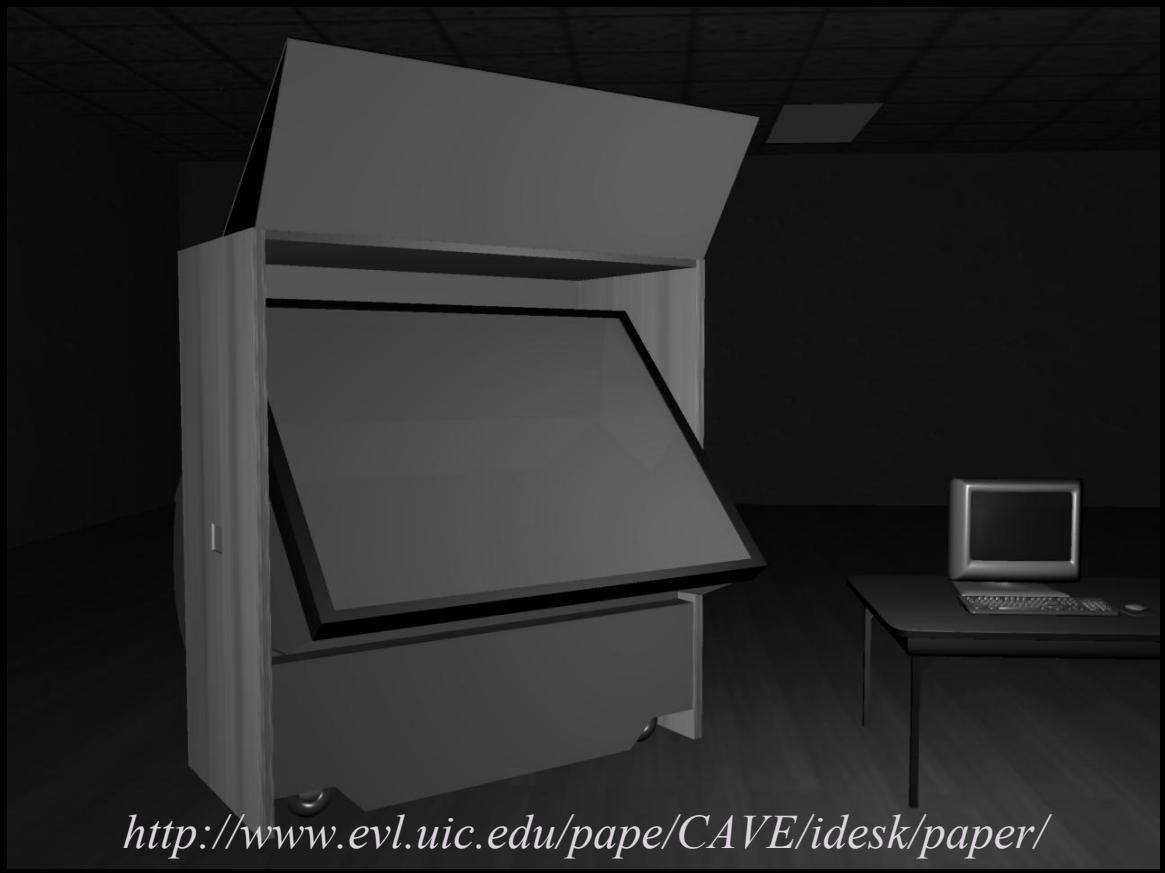
Tele-Immersion Hardware

- Rear Projection System – The ImmersaDesk™
  - 67x50-inch rear-projected screen at a 45-degree angle
  - up to five simultaneous users
- Tracking System – The Spacepad™
  - Electro-magnetic device tracks user's glasses and wand with six degrees of freedom (x, y, z, azimuth, pitch, roll)
- 3D Mouse – Wanda™ VR Input Device
  - Input device control the ImmersaDesk™ system
  - Has three buttons & joystick
- LCD Shutter Glasses – ActiveStereo™ Glasses
  - System Generates 2 images for each user
  - Alternately blocks images, to create stereo effect

ImmersaDesk™ System Elements



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Biomedical Tele-Immersion Methods

- Slice sections digitized
- 3-D Structures segmented
  - by hand or by automatic methods
- 3-Dimensional surface geometry files generated
  - by offline processing or by automatic methods
- Manipulated in Networked ImmersaDesks

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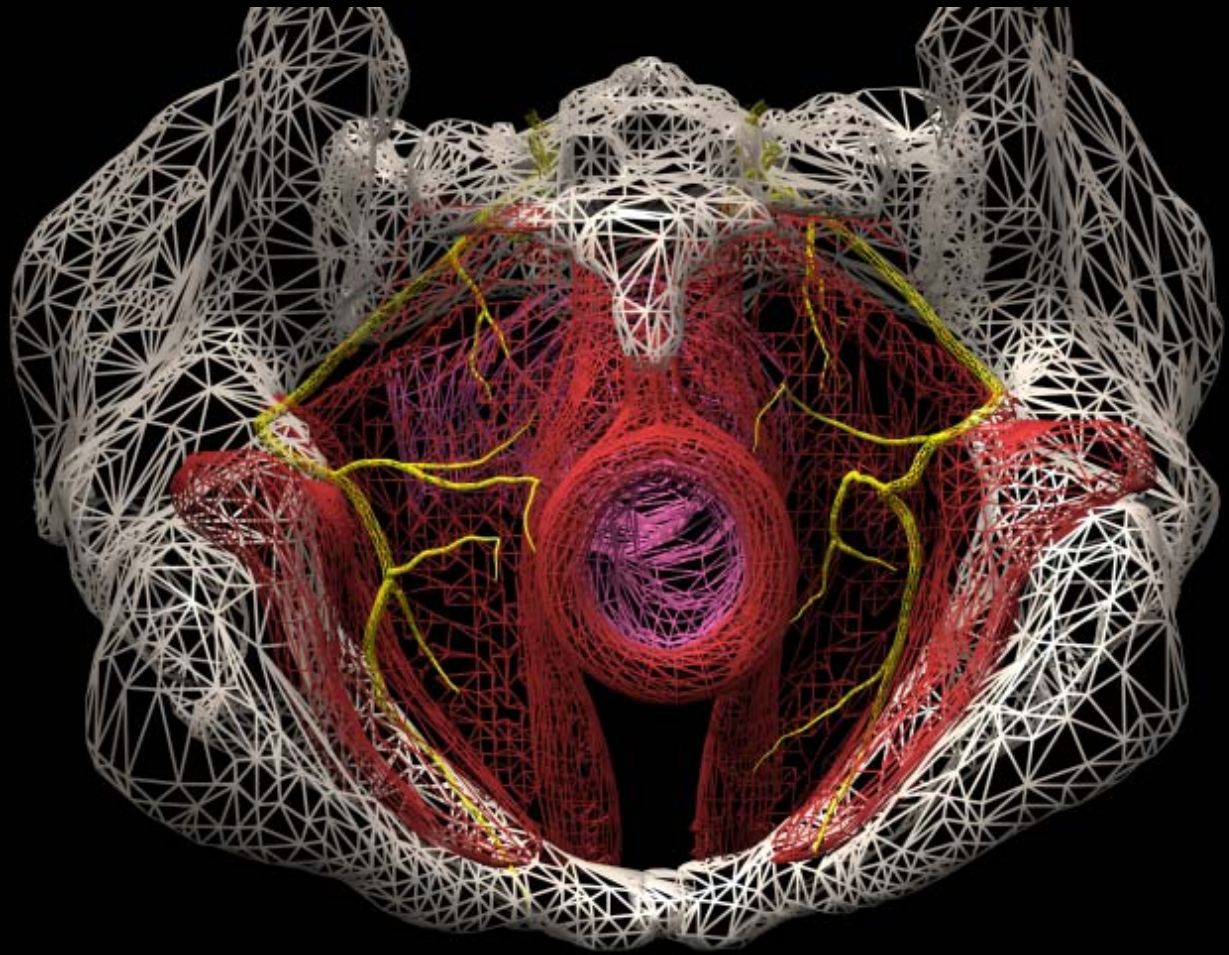
Virtual Pelvic Floor



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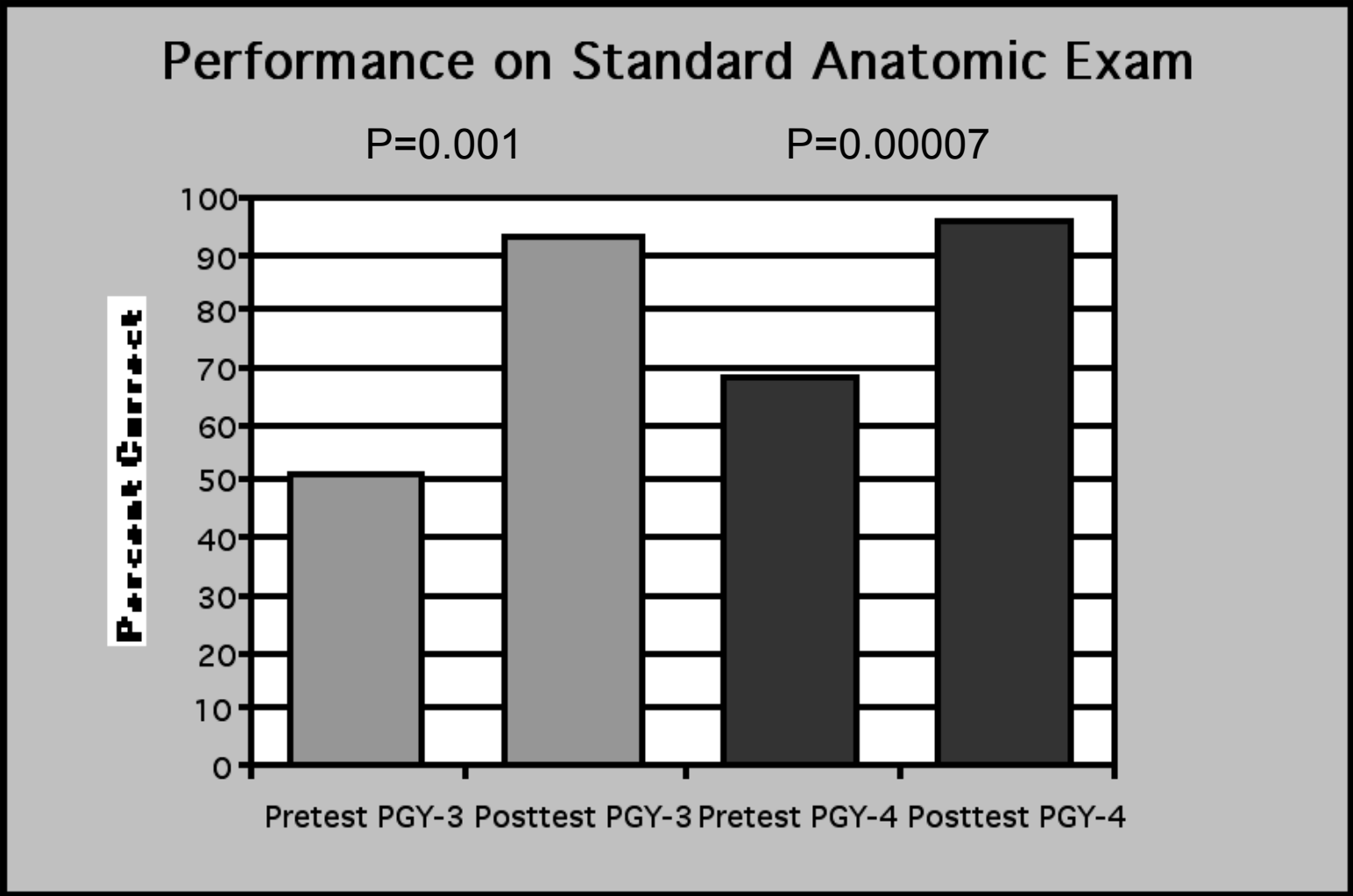

Dobson HD, Pearl RK , Orsay CP, Rasmussen M, Evenhouse R, Ai Z, Blew G, Dech F, Edison MI, ***Silverstein JC****, Abcarian H.Virtual Reality: new method of teaching anorectal and pelvic floor anatomy. Dis Colon Rectum 2003 Mar;46(3):349-52.*

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Virtual Pelvic Floor

Evaluation	Totally Disagree	Disagree	No Opinion	Agree	Totally Agree
Comfortable with technology at start of course	3	1	2	2	5
Comfortable with technology at end of course	0	0	0	5	8
VR technology helped to understand pelvic floor anatomy	0	0	0	2	11
Willing to take another VR technology workshop	0	0	0	2	11

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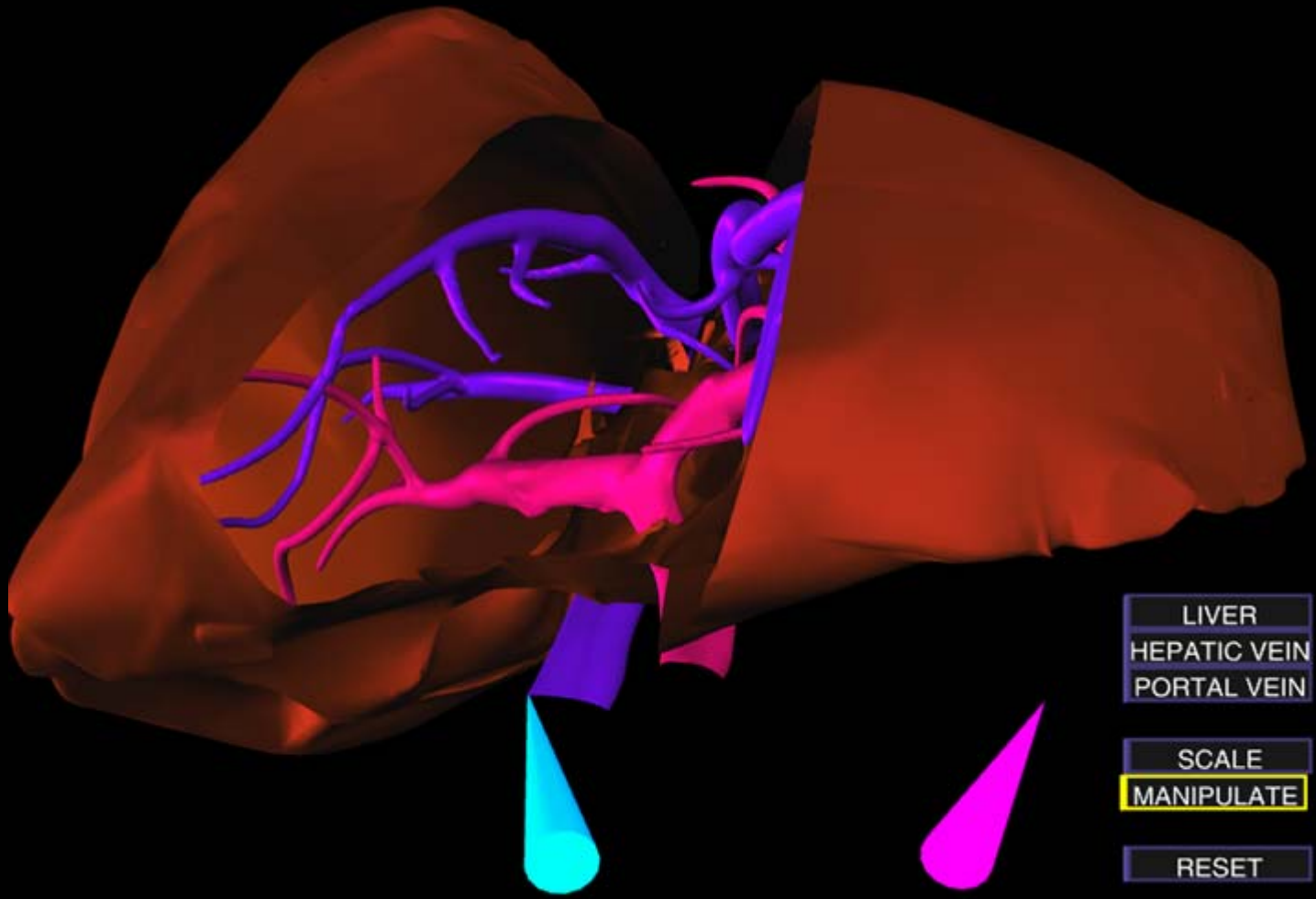
Immersive Hepatic Surgery Educational Environment (IHSEE)



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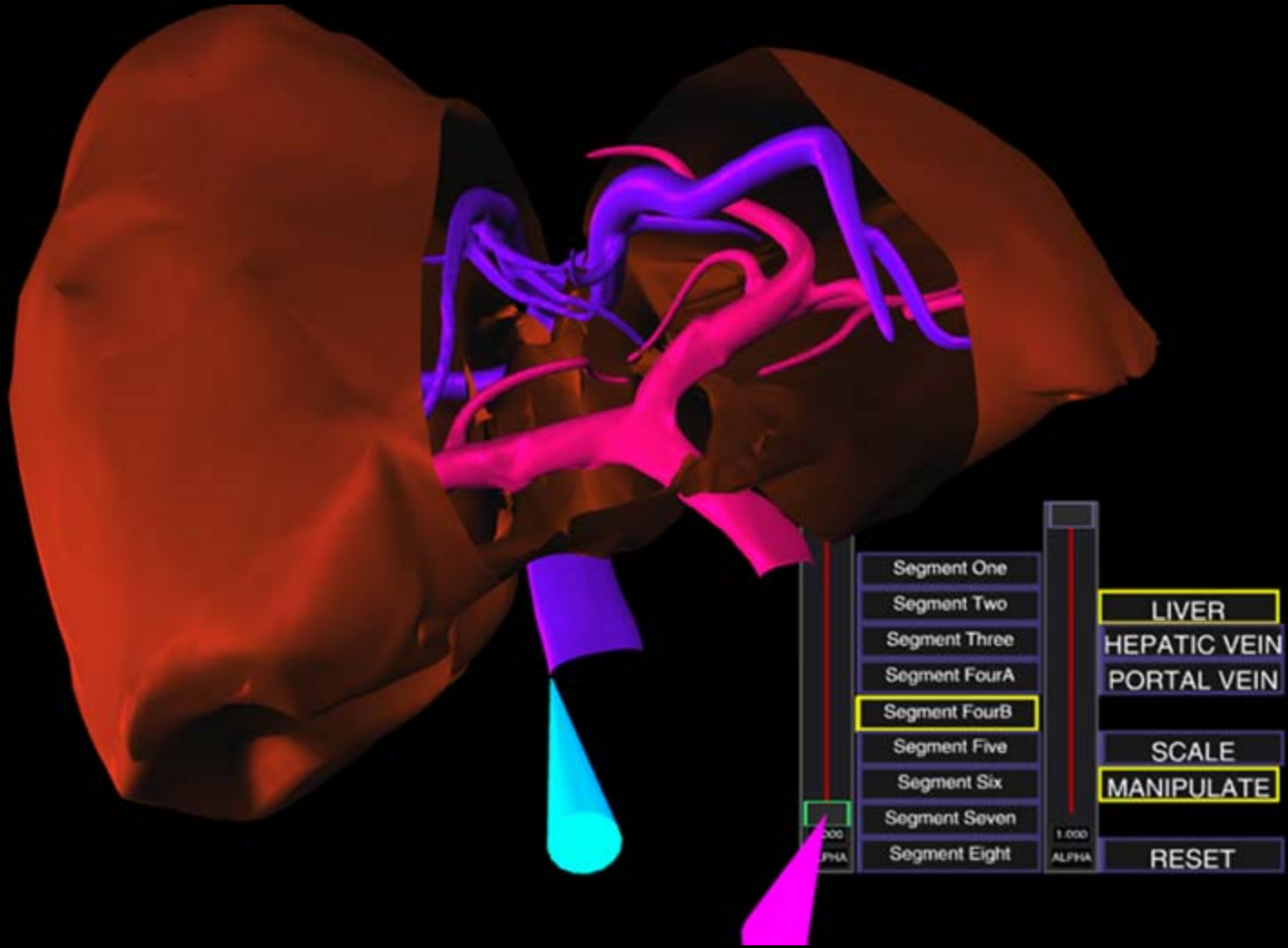
Immersive Hepatic Surgery Educational Environment (IHSEE) - MOVIE



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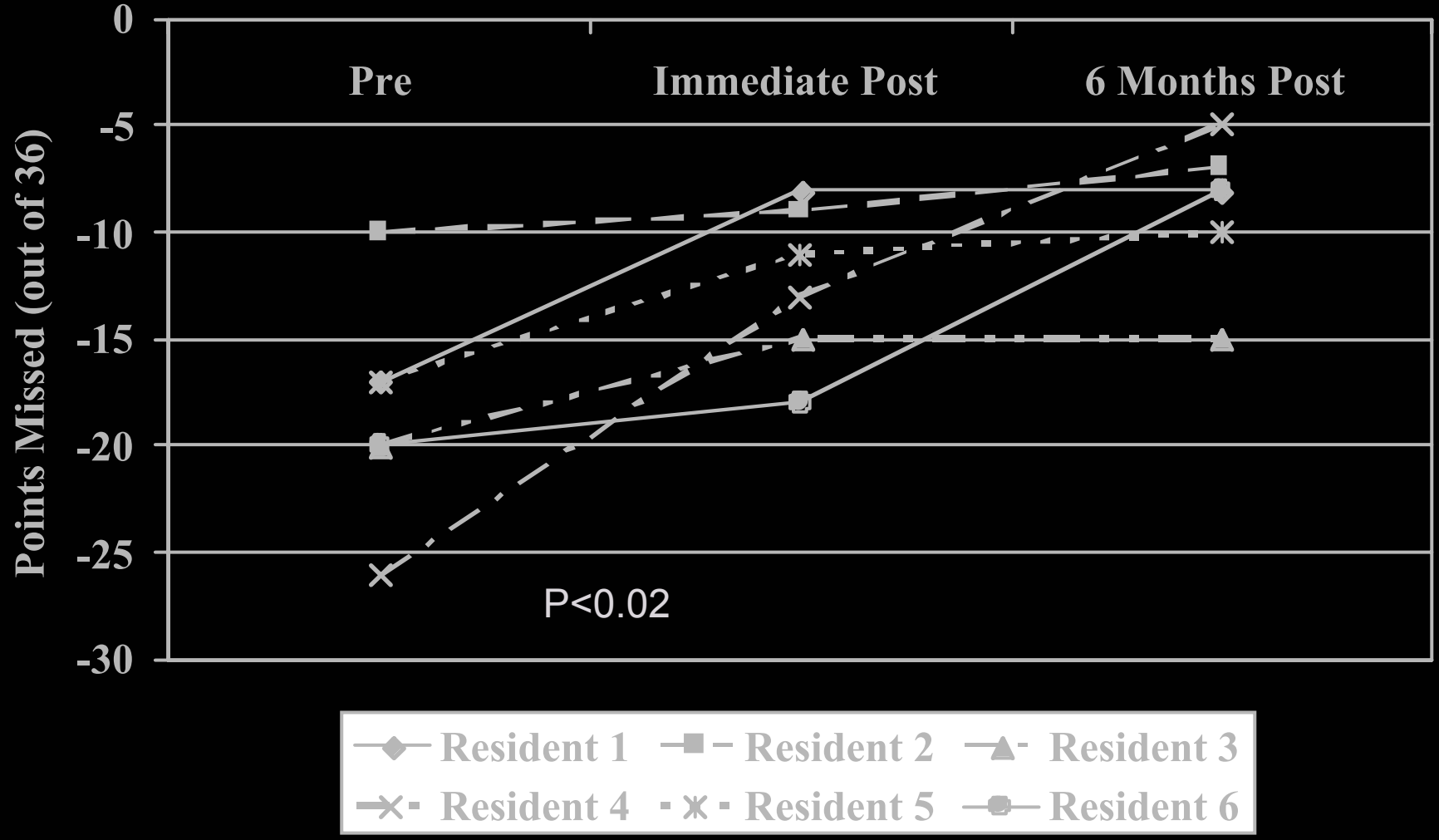
Liver Quiz Results



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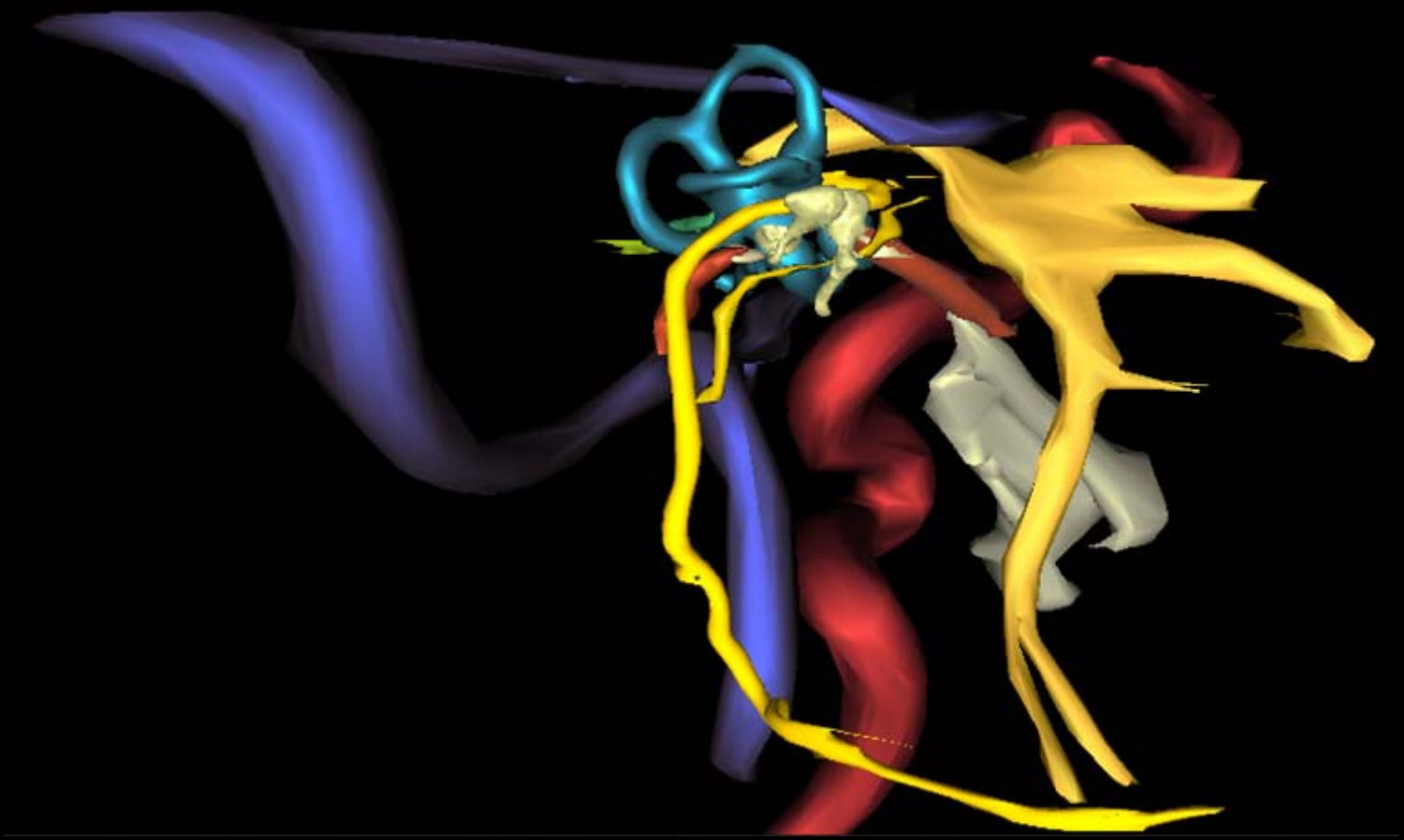
Virtual Temporal Bone



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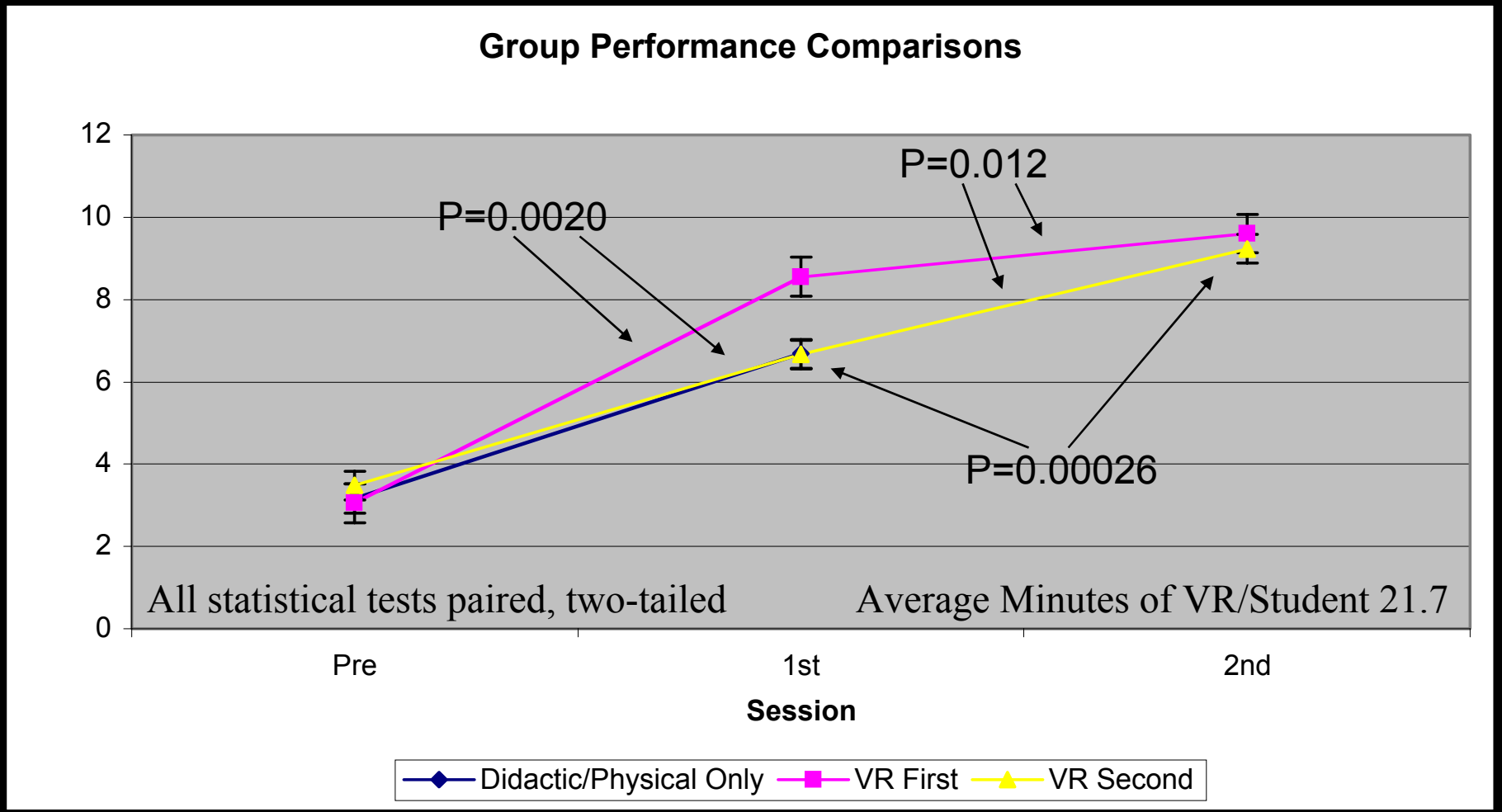
Methods

- Implemented in first year anatomy course
- 87 first year anatomy students volunteered emerging into 3 groups (11 excluded - no post-quiz taken)
  - One group participated in pre and post-quiz only (no additional instruction (27) beyond standard lecture and cadaver lab)
  - Other two groups received a twenty-minute session with the tele-immersive environment before (19) after (30) the standard sessions
- Sessions run by teaching assistants
  - specifically trained to use the technology
  - highlighted the important "true" anatomic locations of landmarks
- Students took quizzes and surveys

Results - Testing Data (Diffs)



(manuscript in preparation)

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Results – Survey Data

1 = Strongly Disagree, 5= Strongly Agree

• I found the instructor easy to understand	4.0
• I found the Tele-Immersive technology an enjoyable way to learn this material	4.4
• The Tele-Immersive technology helped me to better master the subject material	4.3
• I feel that I know more about the material from using this technology than I would have under traditional methods	4.0
• The Tele-Immersive technology is an efficient way to learn the subject matter	4.0
• I would like to take additional courses using this technology	Yes = 45, No = 4

(manuscript in preparation)

Rigorous Exploration of Medical Data in Collaborative Virtual Reality Applications

Distributed, collaborative, stereoscopic visualization and high precision manipulation of volumetric data

Collaborators:

Depts. of Radiology, UIC and UC

Electronic Visualization Lab, UIC

Math & Computer Science Div., ANL

Dech F, Silverstein JC. *Rigorous Exploration of Medical Data in Collaborative Virtual Reality Applications*. IEEE Computer Society Proceedings of 6th Annual Conference on Information Visualisation. 2002. P32-38.

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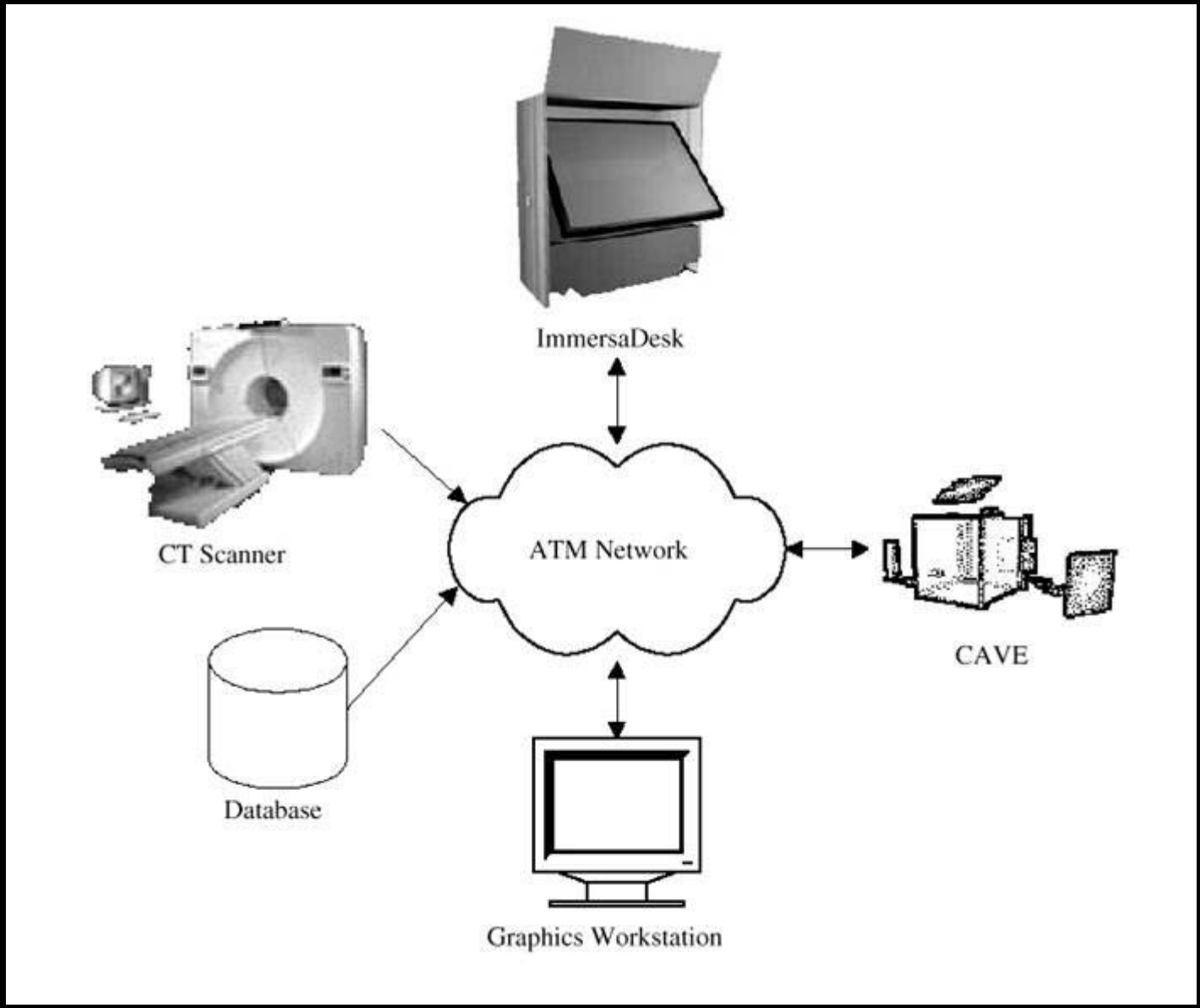
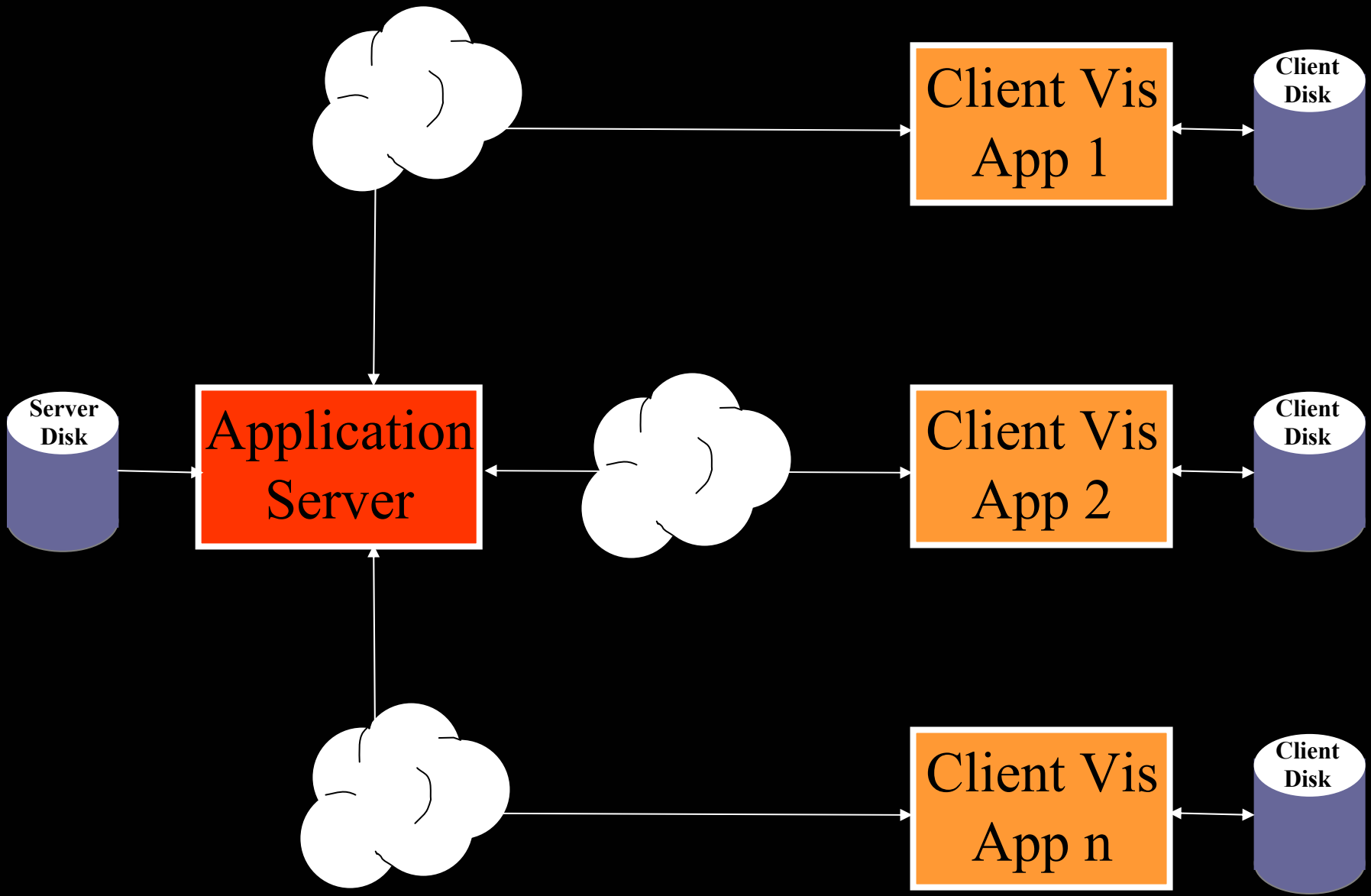

ImmersaDesk
CT Scanner
ATM Network
CAVE
Database
Graphics Workstation



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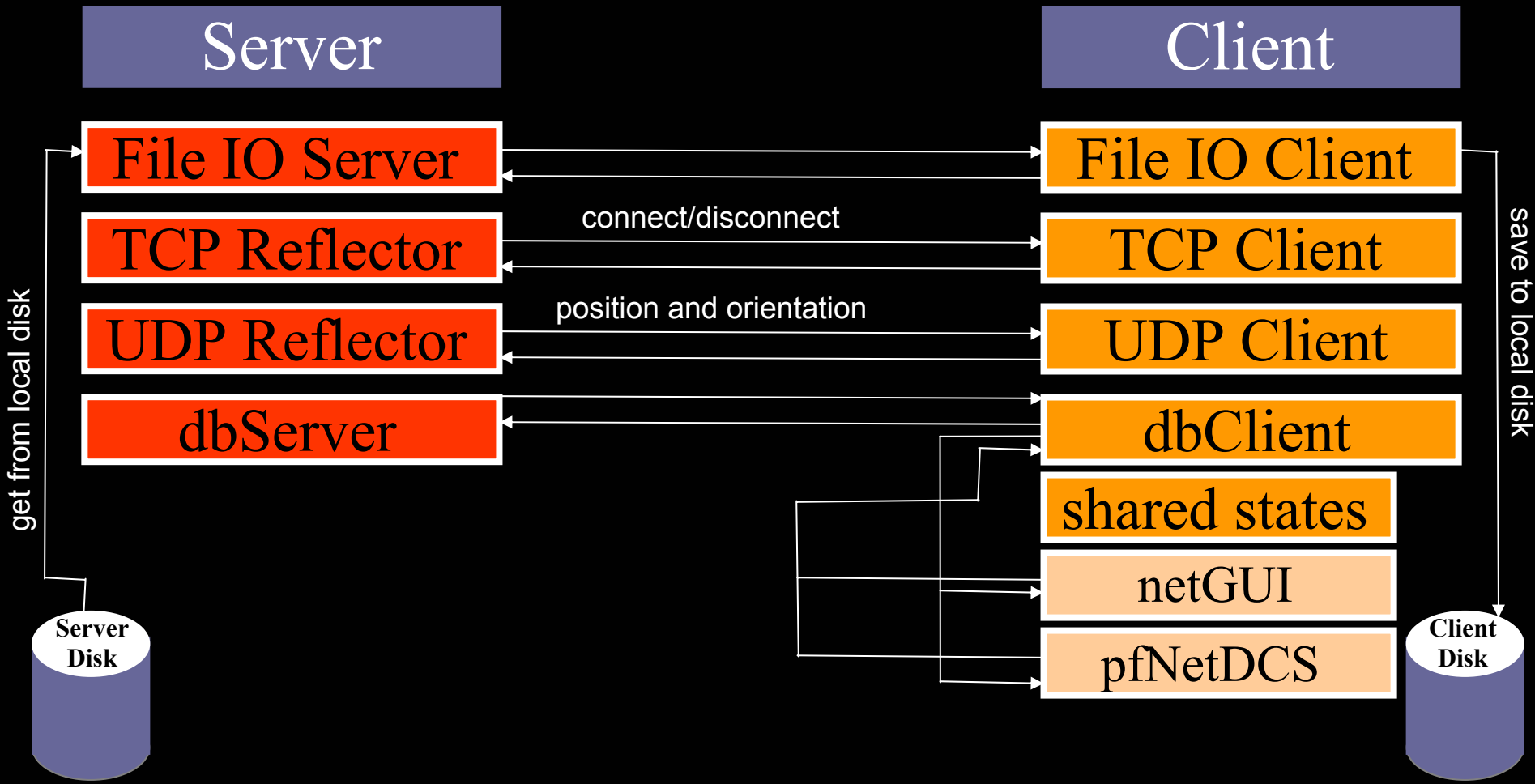
CAVERN G2 Networking Components



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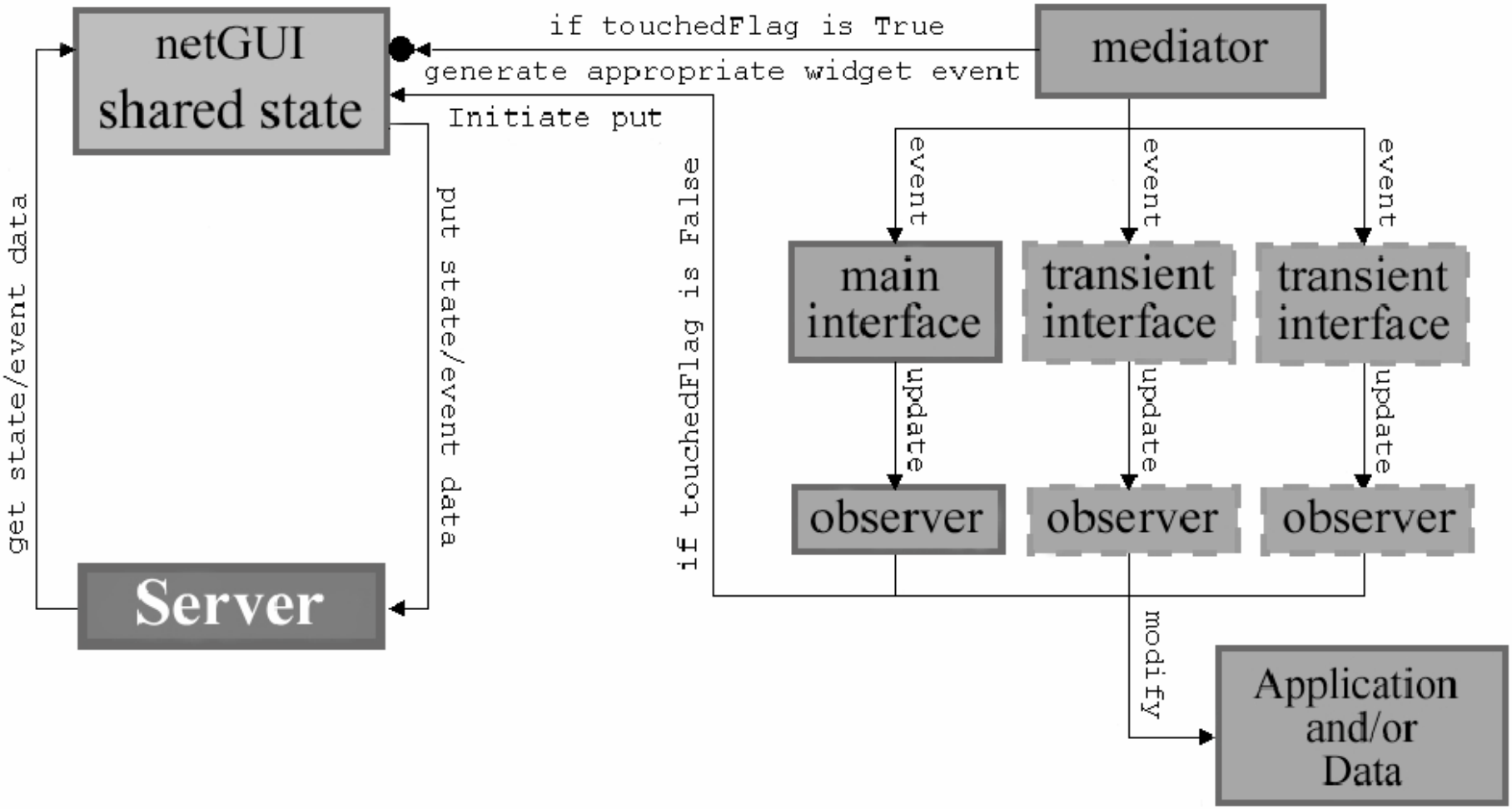
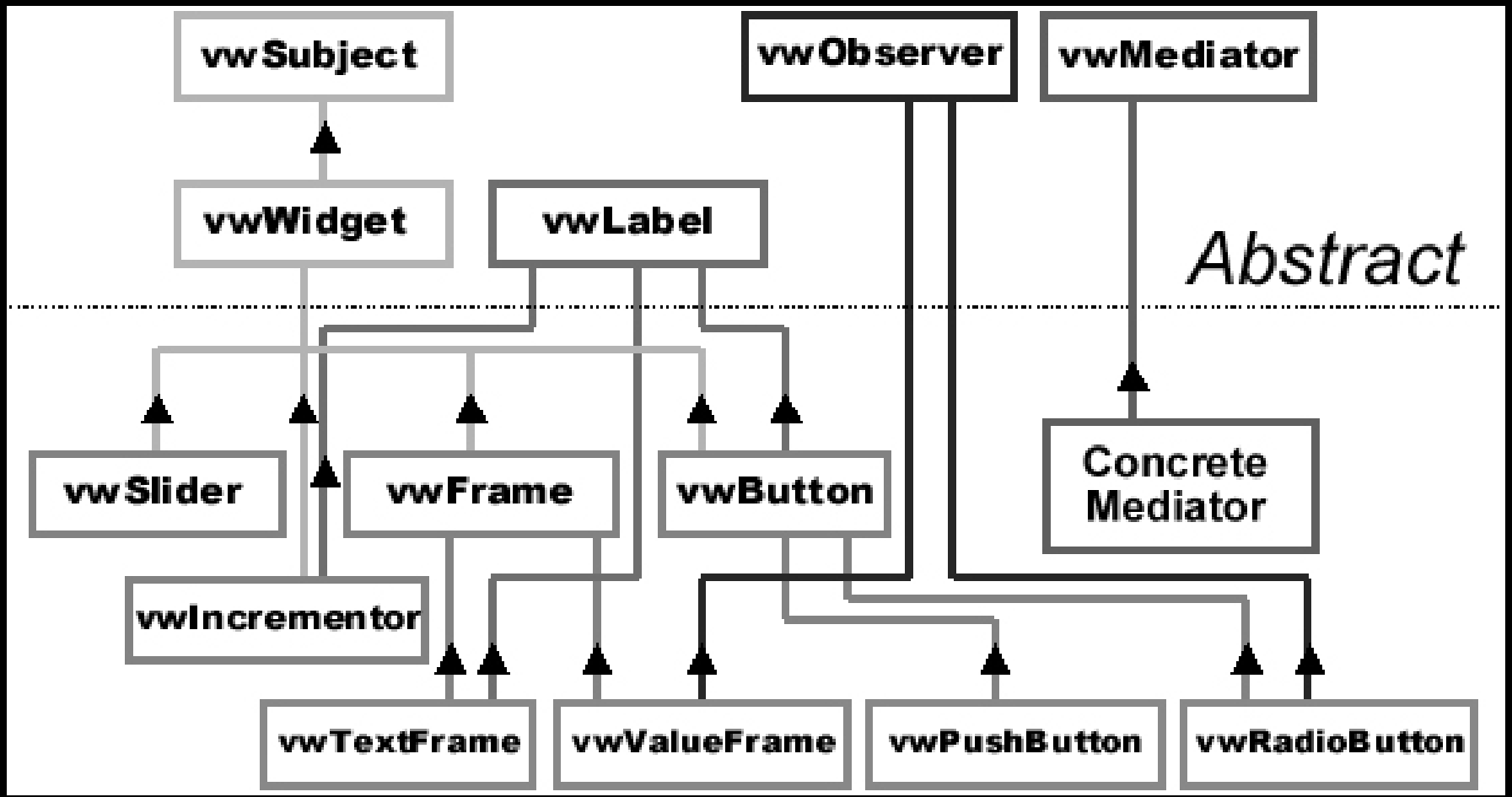
Interface
Event and State Propagation




vwSubject
vwObserver
vwMediator
vwWidget
vwLabel
Abstract
vwSlider
vwFrame
vwButton
Concrete Mediator
vwIncrementor
vwTextFrame
vwValueFrame
vwPushButton
vwRadioButton

Collaborative Virtual Reality Features Implemented

- Persistent Server-Client Tele-Collaboration
  - Distributed application control, Synchronization, Audio and video channels sharing
- Model selection, Transparency of Elements
- Translate, Rotate, Scale
- Automatic DICOM import
- Segmentation
- Region of Interest
- Sampling Precision
- Arbitrary Clipping Plane

Visualization from Visible Human Dataset

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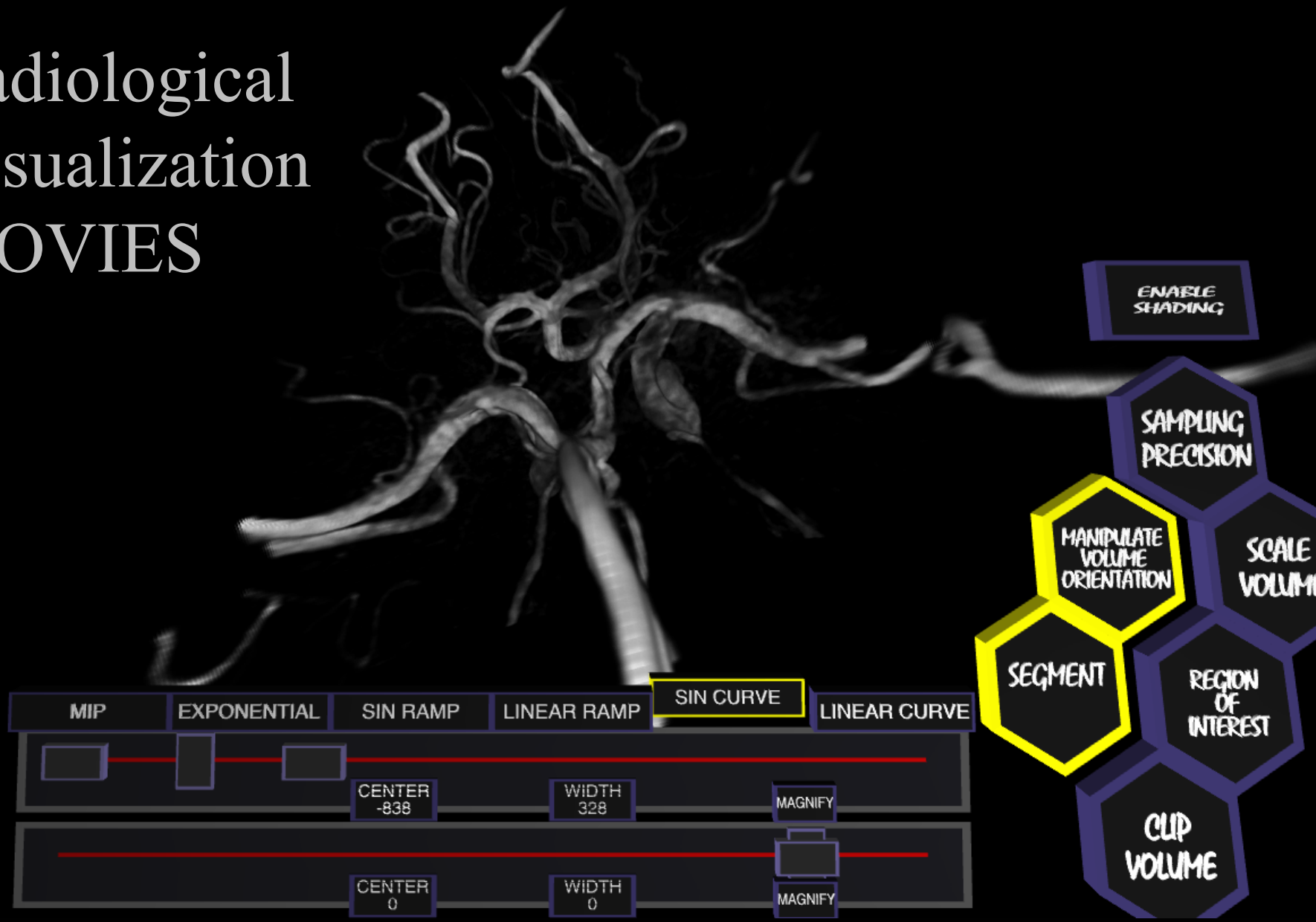
Radiological Visualization MOVIES



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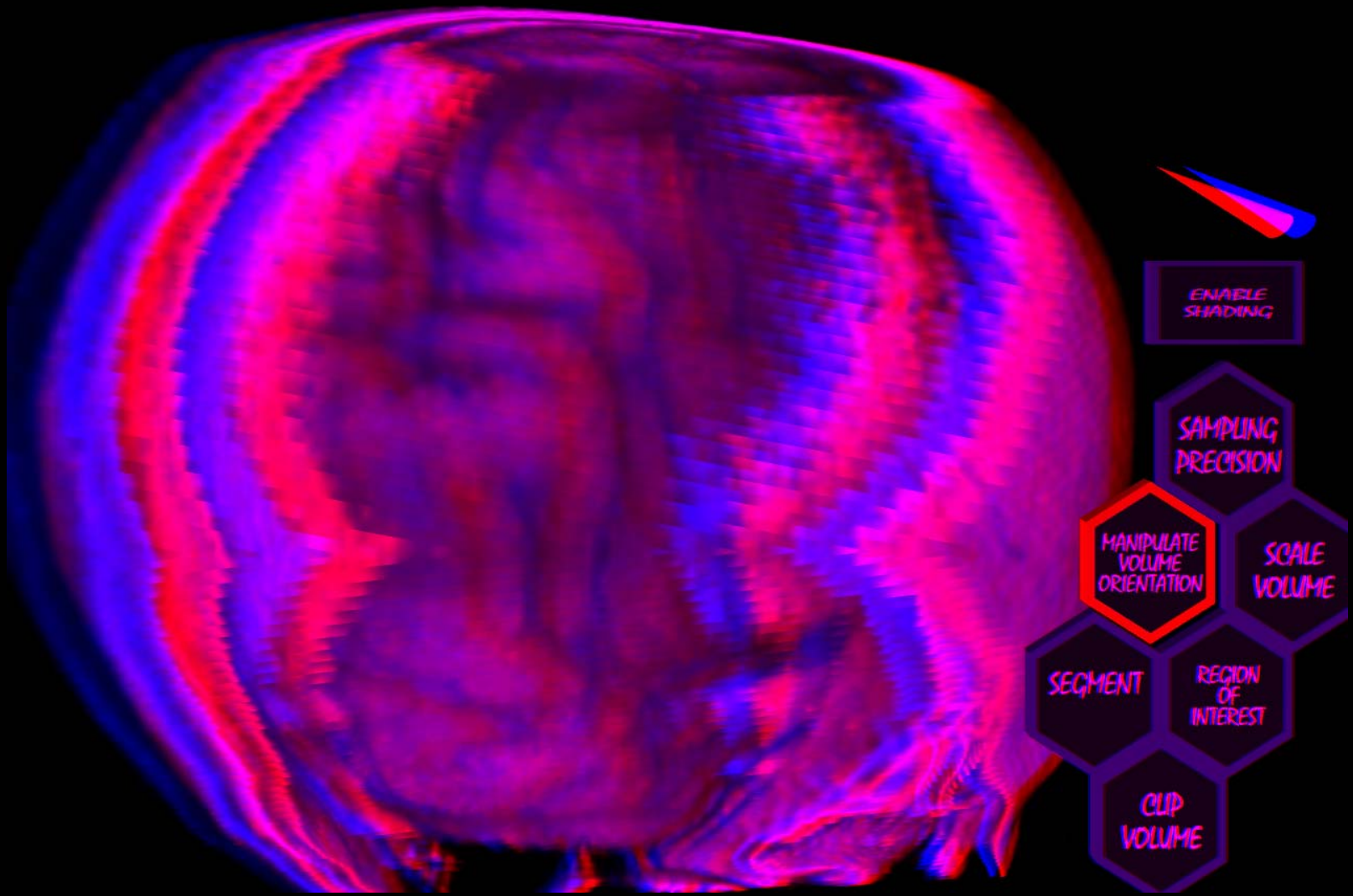

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Stereo Radiological Visualization MOVIE

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Lessons Learned (page 1 of 2)

- Instructors and learners adopt the technology quickly
  - Key messages can avoid distracting or disturbing displays
- Tele-Immersion for surgical/anatomic education is valuable
  - Positive educational outcomes
  - Positive satisfaction outcomes
- It takes less than 30 minutes to effectively demonstrate and interact with a single virtual environment

Lessons Learned (page 2 of 2)

- Live video useful in understanding remote environment (i.e. AccessGrid in concert with Tele-Immersion), but video avatars were simply a distraction

- Advanced network features other than bandwidth are useful (particularly use of multiple protocols in one application)

- Widespread adoption of Biomedical Tele-Immersion is currently limited by hardware features such as expensive proprietary hardware requirements and expert labor

Acknowledgements

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Papers Referenced

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